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TITLE: NAVIGATION SYSTEM THAT
SUPPORTS MULTIPLE
LANGUAGES AND FORMATS

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1   NAVIGATION SYSTEM THAT SUPPORTS
2   MULTIPLE LANGUAGES AND FORMATS

3   BACKGROUND OF THE INVENTION

4   The present invention relates to a navigation system, and more particularly, the

5   present invention relates to a navigation system that includes a centrally-located server

6   that provides language- and format-independent navigation-related information to one or

7   more other servers, which in turn use the language- and format-independent navigation-

8   related information to formulate specific navigation instructions which are provided to

9   end users.

10   Navigation systems provide various useful features, such as calculating routes to

11   desired destinations, providing guidance for following calculated routes, displaying maps,

12   and so on. There are various computer architectures for navigation systems that deliver

13   navigation-related features. In one type of architecture for a navigation system, end users

14   use electronic devices to obtain navigation information from a remotely located server.

15   The end users electronic devices may include general purpose devices, such as cell

16   phones, personal digital assistants (PDAs), personal computers (desktop and portable), as

17   well as special purpose devices, such as specially designed navigation system units.

18   These end users' devices are used to send requests for navigation-related information

19   over a communications network to the remotely located server. The communications

20   network may include the Internet or any other type of communications medium. When

21   the remotely located server receives a request for navigation information from an end

22   user's device, it uses navigation application software programs and geographic data

23   contained in one or more databases to determine a response to the request and then sends

24   the response to the end user over the communications medium. An example of this type

25   of navigation system is disclosed in U.S. Pat. No. 5,543,789, the entire disclosure of

26   which is incorporated by reference herein.

27   This type of navigation system architecture provides several advantages. One

28   advantage relates to providing updated geographic data. There is a continuing need to

1 update the geographic data used by a navigation system. For example, new streets are

2 built, road construction closes roads, detours are established, new businesses open, posted

3 speed limits change, new turn restrictions are established at intersections, streets are

4 renamed, and so on. These kinds of changes can affect travel through a geographic

5 region. Accordingly, the geographic data used by a navigation system should be updated

6 on a regular basis in order to accurately reflect changes in the represented geographic

7 features. A computer architecture in which end users obtain navigation-related services

8 from a single central server affords an advantage with respect to the updating of the

9 geographic data. With a computer architecture in which end users obtain navigation-

10 related services from a central server, updates need to be applied only to the geographic

11 database(s) associated with the central server.

12   Although there are advantages associated with a navigation system architecture in

13 which end users obtain navigation services from a central server, there are considerations

14 that need to be addressed. One consideration relates to providing navigation-related

15 information in a variety of different languages. As an example, some end users may want

16 navigation information in English, whereas other end users may want navigation

17 information in French, Spanish, or another language. Another consideration relates to

18 providing navigation-related information for a variety of formats. As an example, some

19 end users may have systems that support graphical images of maps that illustrate the

20 navigation-related information, whereas other end users may have systems that support

21 only text instructions. It would be preferable that a navigation server support various

22 different languages and various different types of end user systems. However, this can be

23 difficult to accomplish because of the relatively large number of different types of end

24 user systems, as well as the number of different languages. Thus, there is a need for an

25 improvement that facilitates the provision of navigation-related information to different

26 kinds of end user computing platforms and in different languages.

27

28 SUMMARY OF THE INVENTION

29   To address these and other objectives, the present invention comprises a system

30 and method that includes a navigation-related information server that provides

31 navigation–related information in a language- and format independent format. The

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1   navigation-related information server responds to requests for navigation-related

2   information from one or more customer-interface servers. Each customer-interface

3   server receives requests for navigation-related information from end users that have end

4   user computing platforms. The end users send their requests for navigation-related

5   information from end user computing platforms over a data network to the customer-

6   interface servers. In order to respond to the end users, the customer-interface servers

7   request language and format-independent navigation-related information from the

8   navigation-related information server. The navigation-related information server receives

9   the requests from the customer-interface servers. To respond to each request for

10   navigation-related information, the navigation-related information server uses one or

11   more geographic databases to formulate language- and format-independent data

12   structures. These language- and format-independent data structures are sent to the

13   customer-interface servers. The customer-interface servers receive the language- and

14   format-independent responses from the navigation-related information server and

15   formulate language- and format-specific responses that are sent to the end users.

16   In one embodiment, the language and format-independent data structures

17   provided by the navigation-related information server are in XML format. The customer-

18   interface servers use XML style sheets to formulate language and format-specific

19   responses that are sent to the end users.

20

21   BRIEF DESCRIPTION OF THE DRAWINGS

22   Figure 1 is a block diagram illustrating components of an embodiment of a

23   navigation system that provides navigation services to end users' computing devices

24   located throughout a geographic region.

25   Figure 2 is a block diagram showing components of the navigation-related

26   information provider and customer-interface provider in Figure 1.

27   Figure 3 is a block diagram illustrating components of the navigation applications

28   installed on the navigation-related information server of Figures 1 and 2.

29   Figure 4 is a diagram illustrating the components of the route calculation object of

30   Figure 3.

1   Figure 5 is a diagram illustrating the components of the maneuver generation

2   application of Figure 3.

3   Figure 6 is a diagram illustrating the component members of one of the maneuver

4   data structures of Figure 5.

5

6   DETAILED DESCRIPTION OF THE
7   PRESENTLY PREFERRED EMBODIMENTS

8   I.   OVERVIEW OF NAVIGATION SYSTEM

9   Figure 1 shows a geographic region 100. The geographic region 100 may

10   correspond to a metropolitan or rural area, a state, a country, or combinations thereof, or

11   any other area of comparable size. Located in the geographic region 100 is a road

12   network 104.

13   A navigation system 110 serves end users (e.g., vehicle drivers and passengers, as

14   well as other persons and businesses) in the geographic region 100. The navigation

15   system 110 is used by the end users to obtain navigation-related services. The

16   navigation-related services include information about travel along the road network 104,

17   including route calculation and guidance. The navigation-related services may also

18   include people and business finding services (e.g., electronic yellow and white pages),

19   map display, point of interest searching, destination selection, and so on.

20   The navigation system 110 is a combination of hardware, software and data. The

21   navigation system 110 includes remote components, i.e., hardware, software or data

22   located remotely from the end users, and local components, i.e., hardware and/or

23   software located physically with each end user.

24   The local components of the navigation system 110 include the various electronic

25   devices and computer platforms 130 operated by end users to request and obtain

26   navigation-related services using the navigation system 110. These various end user

27   computer platforms (also referred to as "end user electronic devices" or "client

28   computing platforms" or the like) may include general purpose devices, such as cell

29   phones, personal digital assistants (PDAs, PalmPilot®-type devices), personal computers

30   (desktop and portable), as well as special purpose devices, such as specially designed

31   navigation system units located in vehicles 134.

1   The end user devices 130 have the appropriate hardware and software to transmit

2   and receive data over a data network 140. The data network 140 may use any suitable

3   technology and/or protocols that are currently available, as well as technology and/or

4   protocols that become available in the future. For example, the data network 140 may

5   use WAP, TCP/IP, i-mode, etc. More than one protocol may be used in the data network

6   140 with appropriate conversions. The data network 140 may include the Internet.

7   The data network 140 may include a wireless portion 142. The wireless portion

8   142 may be implemented by any suitable form of wireless communication, including

9   cellular, PCS, satellite, FM, radio, or technologies that may be developed in the future.

10   The wireless portion 142 may include one or more transmitters 144, such as a

11   transponder tower, an antenna tower, an FM tower, satellites, or other suitable means.

12   The transmitters 144 include an appropriate communication link 146 to the network 140.

13   This link 146 may be land-based or may be wireless. The transmitters 144 include

14   suitable technology that enables two-way communication with the mobile end user

15   computing platforms 130.

16

17   II.   THE NAVIGATION-RELATED INFORMATION SERVER
18   AND THE CUSTOMER-INTERFACE SERVER

19   The remote components of the navigation system 110 include a navigation-related

20   information server 200 and one or more customer-interface servers 202(1), 202(2) . . . .

21   Figure 2 is a block diagram showing some of the components of the navigation-related

22   information server 200 and one of the customer-interface servers 202(1). (The customer-

23   interface server 202(1) is representative of all the other customer-interface servers, which

24   may have similar or identical components.)

25

26   A.   The customer-interface server 202(1)

27   The customer-interface server 202(1) is maintained and operated by a customer-

28   interface provider 220.

29   The customer-interface server 202 includes a communications system 222. The

30   communications system 222 interfaces with the data network 140. The communications

31   system 222 has the appropriate hardware and software to receive messages from and send

32   messages to the end user electronic devices 130 over the data network 140. The

1 communications system 222 is also capable of receiving messages from and sending

2 messages to the navigation-related information server 200. In one embodiment, the

3 network used by the customer-interface server 202(1) to communicate with the

4 navigation-related server 200 is the same data network (i.e., network 140) used to

5 communicate with the end user electronic devices 130.

6   Included on the customer-interface server 202(1) are customer-interface

7 applications 230. One of the customer-interface applications 230 is a subscriber services

8 application 234. In order to use some or all of the services provided by the customer-

9 interface provider 220, end users may be required to be subscribers. The subscriber

10 services application 234 provides services that support this function. Some of the

11 subscriber services include enrollment, payments, renewals, confirmation of subscriber

12 status, targeted advertising, and so on. The subscriber services application 234 may use a

13 subscriber database 235 that contains various kinds of information concerning the various

14 subscribers.

15   Also included among the customer-interface applications 230 on the customer-

16 interface server 202(1) are data conversion applications 240. The data conversion

17 applications 240 receive the messages requesting navigation-related services from the end

18 users devices 130, extract pertinent content regarding the type of navigation-related

19 information desired by the end users, and formulate requests to send to the navigation-

20 related information server 200 for the navigation-related data needed to response to the

21 end user requests. The data conversion applications 240 also receive data messages

22 containing navigation-related data from the navigation-related information server 200,

23 extract the navigation-related information from the messages received from the

24 navigation-related information server 200, formulate meaningful language- and format-

25 specific navigation guidance or other information for the end users, and transmit the

26 meaningful language- and format-specific guidance or other information to the end user

27 computing platforms 130. The data conversion applications 240 are described in more

28 detail below.

29

1   B.   The navigation-related information server

2   The navigation-related information server 200 is maintained and operated by a

3 navigation-related information provider 260.

4   The navigation-related information server 200 includes a communications system

5 266. The communications system 266 interfaces with the data network 140. The

6 communications system 266 associated with the navigation-related information server

7 200 has the appropriate hardware and software to receive messages from and send

8 messages to customer-interface server 202(1), as well as the other customer-interface

9 servers 202(2) . . . over a data network, which in one embodiment is the data network

10 140.

11   Associated with the navigation-related information server 200 are one more

12 geographic databases 270. The geographic databases 270 are stored on media which may

13 be located with the navigation-services server 200. Various storage media may be used,

14 including fixed or hard disks, DVD disks or other currently available storage media, as

15 well as storage media that may be developed in the future.

16   The geographic databases 270 include information about the roads and

17 intersections in or related to one or more geographic regions or coverage areas (such as

18 the geographic region 100 in Figure 1). This information includes data specifying the

19 positions of the roads in the covered geographic region and also includes data about

20 features relating to the roads, such as restrictions on directions of travel on the roads (e.g.,

21 one-way streets), turn restrictions, street addresses, street names, speed limits, and so on.

22 The geographic databases 270 may also include information about points of interest in

23 the geographic areas, such as hotels, restaurants, museums, stadiums, offices, automobile

24 dealerships, auto repair shops, etc. The geographic databases 270 may also include

25 information about places, such as cities, towns, or other communities. The geographic

26 database 270 may include other data about the geographic region.

27   In one embodiment, the geographic databases 270 and the data contained therein

28 are provided by Navigation Technologies Corporation of Chicago, Illinois. However, it

29 is understood that databases developed and provided by other entities may also be

30 suitable for use with some of the embodiments disclosed herein.

1   The geographic databases 270 may take a variety of different forms and/or

2   formats. The geographic databases may be organized in one or more formats in order to

3   facilitate the provision of various navigation-related information and functions. Methods

4   of organizing a geographic database to enhance the performance of certain navigation-

5   related functions are described in U.S. Pat. Nos. 5,974,419, 5,968,109 and 5,953,722, the

6   entire disclosures of which are incorporated by reference herein.

7   One format that may be used for organizing the geographic databases 270 is the

8   SDAL® format provided by Navigation Technologies Corporation. The present

9   embodiments are not limited to any particular format and other formats may be used.

10

11   III.   THE NAVIGATION APPLICATIONS

12   Associated with the navigation-related information server 200 are navigation

13   applications 280. The navigation applications 280 may be formed of separate component

14   applications (also referred to as programs, subprograms, routines, or tools). The

15   navigation applications 280 work together through defined programming interfaces. The

16   navigation applications 280 use the geographic databases 270 associated with the

17   navigation-related information server 200 in order to provide the various different types

18   of navigation-related information.

19   Figure 3 shows some of the navigation-related applications 280 on the navigation-

20   related information server 200. In addition to the applications shown in Figure 3, the

21   navigation-related information server 200 may include other navigation applications.

22   The navigation applications 280 are programs that provide for specific navigation

23   functions to be performed by the navigation-related information server 200. In the

24   embodiment of Figure 3, the navigation applications 280 request and obtain data from the

25   geographic database 270 and use the data to satisfy the requests for navigation

26   information from the customer-interface servers 202(1), 202(2) . . . . The navigation

27   applications 280 may obtain the geographic data directly from the geographic database

28   270, or alternatively, the navigation applications 280 may obtain the data through an

29   interface layer 284 and an operating system 286.

30   As shown in Figure 3, the navigation applications 280 include a manager

31   application 288. The manager application 288 is a program or routine that provides for

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1   an overall interface to the navigation applications on the navigation-related information

2   server 200.

3   Among the navigation applications 280 on the navigation-related information

4   server 200 is a route calculation application 290. In the embodiment of Figure 3, the

5   route calculation application 290 receives its input from the navigation manager 288.

6   The route calculation application 290 receives input in the form of data that identify at

7   least an origin and a desired destination. The route calculation application 290 may also

8   receive additional input information that affects the calculation of the route. For

9   example, the additional input to the route calculation application 290 may include data

10   that specify user preferences such as avoidance of toll roads or expressways, and so on.

11   The input may also include data that identifies the time of day at which the route will be

12   started which may affect the route calculation.

13   Given data that identify the positions of an origin and destination, the route

14   calculation application 290 uses data from the geographic databases 270 to calculate a

15   route between the origin and the destination. The route calculation application 290 may

16   use any of various means or algorithms for this purpose. For example, the route

17   calculation application 290 may use either the A* algorithm or the Dykstra algorithm.

18   Alternatively, the route calculation application 290 may use the methods for calculating

19   routes disclosed in U.S. Pat. No. 6,192,314, the entire disclosure of which is incorporated

20   by reference herein. The methods disclosed in U.S. Pat. No. 6,192,314 represent only

21   some of the ways that routes can be calculated and the claimed subject matter herein is

22   not limited to any particular method of route calculation. Any suitable route calculation

23   method now known or developed in the future may be employed.

24   Regardless of the method used, the route calculation application 290 provides an

25   output in the form of a list identifying a continuous series of roads (or segments thereof)

26   that form a legally valid solution route between an origin and a destination. A "legally

27   valid solution route" conforms to known traffic restrictions, such as one way streets, turn

28   restrictions, etc. The method used by the route calculation application 290 may be

29   designed to optimize the solution route to meet one or more predetermined criteria. Such

30   criteria may include the least travel time, the shortest distance, the fewest turns, etc. If

31   the method used by the route calculation application 290 is designed to find a solution

1   route that is optimized for one or more criteria, then the solution route also ideally meets

2   these one or more criteria.

3   In the embodiment of Figure 3, the output of the route calculation application 290

4   is in form of a route calculation object 302. Figure 4 is a diagram representing the

5   components of the route calculation object 302. The route calculation object 302

6   contains an ordered list 304 identifying a plurality of road segment data entities (i.e.,

7   *seg1, seg2, seg3 . . . seg(n)*). The plurality of data entities represent the road segments

8   that form the continuous navigable route between the origin and the destination that had

9   been calculated by the route calculation application 290. Since these segments form a

10   continuous route, each segment shares a node with its successor segment in the list. For

11   example, as shown in Figure 4, the segments *"seg2"* and *"seg3"* are shown to have a

12   common node *"N3."* The route calculation object 302 may include other information

13   306 in addition to the ordered list of road segment data entities.

14   Referring to Figure 3, the route calculation object 302, which is created by the

15   route calculation application 290, is used as an input to the route guidance application

16   310. (The route guidance application 310 is another of the navigation applications 280.)

17   The route guidance application 310 is comprised of a maneuver generation application

18   320. The maneuver generation application 320 uses as its input the route calculation

19   object 302 formed by the route calculation application 290. (Methods for providing the

20   functions performed by the maneuver generation application 320 are disclosed in U.S.

21   Pat. No. 6,199,013, the entire disclosure of which is incorporated by reference herein.

22   The maneuver generation application 320 describe herein is similar to the subject matter

23   disclosed in the referenced patent.)

24   The maneuver generation application 320 performs at least two functions. The

25   maneuver generation application 320 uses the information in the ordered list 304 of

26   segment data entities in the route calculation object 302 to determine which locations

27   along the calculated route should be explicated to the end user with a maneuvering or

28   advisory instruction. In addition, for each of the locations determined as requiring

29   explication, the maneuver generation application 320 collects information needed to

30   provide a maneuvering or advisory instruction for the particular location.

1   In performing these functions, the maneuver generation application 320 uses two

2   objects. Referring to Figure 5, the maneuver generation application 320 includes a

3   (maneuver generation) configuration object 330 and maneuver generation object 340.

4   The (maneuver generation) configuration object 330 contains maneuver rules 332. These

5   maneuver rules 332 are applied using the data in the route calculation object 302 and

6   from the geographic database 270. These rules determine when a location along the

7   calculated route should be explicated with a maneuvering instruction. As mentioned

8   above, the route calculation object 302 contains the list 304 of data entities that represent

9   segments of roads. Because this list represents road segments that form a continuous

10   route, each road segment represented by a data entity in the list 304 shares a node (i.e., an

11   "endpoint") with a road segment represented by an adjacent data entity in the list. The

12   maneuver rules 332 are applied at each of these nodes in the list 304.

13   In applying the maneuver rules 332, the direction of travel of the calculated route

14   is taken into account. Thus, the segment by which the calculated route leads into the

15   node being tested by the maneuver rules 332 is identified as the entry segment. The

16   segment by which the calculated route leads out of the node being tested by the maneuver

17   rules 332 is identified as the exit segment. In addition, all the other road segments that

18   are not part of the calculated route, but that share this same node with the entry and exit

19   segments are identified. The data entities that represent all these road segments are

20   obtained from the database 270.

21   The maneuver rules 332 are provided in the form of a table 333. The table 333

22   defines a plurality of maneuver types 334 and a plurality of maneuver condition tests 335.

23   Each of these maneuver types 334 characterizes a particular kind of roadway

24   configuration change that can occur at the node being tested from the calculated route.

25   Each maneuver type 334 is assigned a unique code or number.

26   Each of the maneuver condition tests 335 is formulated to accept only a positive

27   or negative answer. Each maneuver type 334 defined in the table 333 is associated with a

28   unique subset of the plurality of maneuver condition tests 335. Each maneuver condition

29   test 335 uses the data in the data entities which had been obtained from the database 270

30   (such as the data associated with the entry segment, the exit segment, the accessible and

31   inaccessible segments, and so on) to ascertain whether the condition specified in the

1   maneuver condition test is satisfied. For each node in the calculated route 304, if all the

2   maneuver condition tests associated with a maneuver type 334 are satisfied, a maneuver

3   instruction is required for that the node location.

4   For each of the locations determined by the maneuver generation application 320

5   to require explication, the maneuver generation application 320 forms a maneuver data

6   structure 350 and adds the maneuver data structure to the maneuver generation object

7   340. Each maneuver data structure 350 formed by the maneuver generation application

8   320 contains the information needed to provide a maneuvering instruction to the end user

9   at the location along the route at which explication has been determined to be provided to

10   the end user. Some of the data required for the maneuver data structure is included in or

11   derived from the segment data entities that were tested to determine whether a

12   maneuvering instruction is required at the location of the node. Additional data may be

13   required to be obtained or derived from the database 270 by the maneuver generation

14   configuration object.

15   Figure 6 shows the kinds of data contained in each maneuver data structure 350.

16   In one embodiment, the maneuver data structure 350 is formed as a C data structure.

17   Using data from the segment data entities that share the node associated with the

18   maneuver, as well as any additional data needed or derived from the geographic database,

19   the maneuver generation object 340 collects data corresponding to the various members

20   of the maneuver data structure 350. Data are collected to the extent they are available.

21   Members of the data structure may be left empty if there is no data available (e.g., if one

22   of the roads at a maneuver location is unnamed).

23   Included in the data structure 350 is a field 350(1)(1) that identifies the number of

24   segments that meet at the node. The entry and exit segments 350(1)(2), 350(1)(3) into

25   the node are identified. For each of the segments (entry and exit), the data structure 350

26   provides for identifying the name(s) of the segment (if any) 350(2)(2), sign(s) on the

27   segment (if any) 350(2)(3), the rank of the segment 350(2)(4), the segment classification

28   relative to the entry segment (exit, accessible, inaccessible) 350(2)(5), the database

29   classification of the segment (e.g., controlled access, street, ramp) 350(2)(6), and the

30   angle of the segment relative to the entry segment 350(2)(8). In addition, the data

31   structure 350 also includes a field that can be used to identify the maneuver type (as

1   described above) 350(4)(2), the distance to the next maneuver 350(4)(4), and whether the

2   maneuver is included in a multiple maneuver 350(4)(1). (A multiple maneuver may be

3   defined by the maneuver generator object when a location at which a maneuvering

4   instruction is determined to be required is so close to an another adjacent location at

5   which a maneuvering instruction is determined to be required that it may be preferable to

6   present the two, or more, maneuver instructions to the end-user at the same time. The

7   distance at which a multiple maneuver is defined is configurable and may be a function

8   of various factors, including speed limits along the road segments, distance, rank, and so

9   on.)

10   The data structure may also include fields for providing context information

11   350(3) for the exit road. This kind of information may be useful when the other

12   information in the maneuver structure is not sufficient to describe the exit fully, such as

13   when the exit segment is unnamed. The fields for context information may include a

14   destination string 350(3)(1) which describes the exit of the maneuver in cases where the

15   exit segment name is not sufficient (such as when it is unnamed). The context

16   information 350(3) may also include a field for a "location" 350(3)(2) which gives the

17   location of the exit relative to another road (e.g., before, after, ahead, behind, on the right,

18   or on the left). The context information 350(3) may also include a field for a "turn angle"

19   350(3)(3) which gives the angle to be taken to go onto the exit road. The context

20   information may also include a field for a "heading" 350(3)(5) which can be used during

21   the starting-off maneuver and provides the initial heading to be taken (e.g., north, south,

22   east, west, northwest, etc.) The context information 350(3) may also include a field for

23   "relative to" 350(3)(4). The "relative to" field 350(3)(4) is meant to be used in a starting

24   off maneuver. The "relative to" field 350(3)(4) gives an initial intersection to be traveled

25   toward. It can also be used in cases where the exit segment is unnamed (e.g., "turn right

26   after Main Street"). The context information 350(3) may also include a field for "number

27   of exits" 350(3)(6) which can be used for roundabout maneuvers. This "number of exits"

28   field 350(3)(6) includes the number of exits to be passed traveling along a roundabout

29   before reaching the desired exit.

30   In addition to the members mentioned above, the maneuver data structure 350

31   may include additional members 350(5).

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1   The maneuver data structure also includes information for providing advisories.

2   Advisories are types of useful explication information that are not necessarily associated

3   with a maneuver. Advisories may be provided when there is a change in the road

4   network, but a specific driving maneuver is not required. For example an advisory may

5   be provided when entering or leaving a bridge or a tunnel. The maneuver data structure

6   350 includes a field that includes a listing 350(4)(3) of one or more advisory types.

7   Referring again to Figure 5, in addition to the maneuver rules 332 which are used for

8   determining whether to explicate a maneuver at a particular node and forming the data

9   structures 350 therewith, the maneuver configuration object 330 also includes advisory

10   rules 370. The advisory rules 370 are applied to each of the nodes in the route calculation

11   object 342. Like the maneuver rules 332, the advisory rules 370 are in the form of a table

12   372. The advisory rules table 372 includes a set of advisory types 376 and a set of

13   advisory condition tests 378. Each advisory type 376 characterizes a particular kind of

14   advisory that can be provided at a node. Each advisory type 376 is assigned a unique

15   code or number. Each of the advisory condition tests 378 is formulated so as to permit

16   only positive and negative results. A unique subset of the advisory condition tests 378 is

17   associated with each different advisory type 376. If positive results are obtained for all

18   the advisory condition tests associated with an advisory type 376, that advisory type 376

19   is associated with the maneuver at that location.

20   Unlike the rules for maneuvers, the rules for advisories do not require a unique

21   result. Thus, for a given location along a route, there may be one advisory type, multiple

22   advisory types, or no advisory type. The number or code for each advisory type 376 is

23   included in the data structure 350 formed for that location.

24   The application of the advisory rules is independent of the application of the

25   maneuver rules. Thus, application of the advisory rules can require that an advisory

26   instruction be provided at a location along a route even if the application of the maneuver

27   rules at the same location does not require that a maneuvering instruction be provided. If

28   application of the advisory rules requires that an advisory instruction be provided at a

29   location, but application of the maneuver rules at the same location does not require that a

30   maneuvering instruction be provided, a maneuver data structure is formed for that

31   location containing data for the members of the data structure to the extent the data are

14

1   available. A maneuver data structure formed for such a location would have a maneuver

2   type of "0."

3   The maneuver generation configuration object 340 traverses the list 344 of data

4   entities in the route calculation object 342 so that each node along the calculated route is

5   tested with the maneuver rules 332. A maneuver data structure 350 having information

6   for each of the fields identified above (to the extent such information is available) is

7   formed for each location in the calculated route at which the all the maneuver condition

8   tests for any of the maneuver types or all the advisory condition tests for any of the

9   advisory types are satisfied. The maneuver data structures 350 formed by this process are

10   contained in order in the maneuver generation object 340.

11   Referring again to Figure 3, the maneuver generation object 340 is provided to a

12   builder application 400. The builder application 400 is included on the navigation-related

13   information server 200. The builder application 400 takes the maneuver generation

14   object 340 provided from the maneuver generation application 320, extracts the

15   information from the maneuver generation object 340, forms a language- and format

16   independent data structure 420 that contains the information from the maneuver

17   generation object 340 and outputs the language- and format independent data structure

18   420. In the embodiment of Figure 3, the builder application 400 is an XML (eXtensible

19   Markup Language) builder class and the language- and format independent data structure

20   420 is an XML string. The language- and format independent data structure 420 is

21   distributed in at least two ways. These two ways include saving the generated string 420

22   into a file or sending the generated string 420 to its caller, i.e., the customer-interface

23   server 202.

24   In one embodiment the builder application 400 is implemented using C++. In this

25   embodiment, the builder application 400 includes an XML generator 440. The XML

26   generator 440 takes the maneuver generation object 340 and creates the string 420. The

27   string 420 contains the XML representation of the maneuver object 340 that is passed to

28   the communications system 266 for transmission to the customer-interface provider 220.

29   The following example shows the contents the XML structure. These element

30   names would be referenced in the XML Stylesheet used by the customer-interface

31   provider.

```
 1
 2                                    Example
 3   <Direction>
 4     <Source>1975 ORCHARD ST, DES PLAINES IL</Source>
 5     <Destination>1368 N WESTERN AVE, PARK RIDGE IL</Destination>
 6     <Maneuver id="1">
 7        <ManeuverType>0</ManeuverType>
 8        <Advisory>
 9           <Type>7</Type>
10        </Advisory>
11        <Node>
12           <ExitSegmentInfo>
13              <SegmentName>ORCHARD ST</SegmentName>
14              <NameChangedFlag>1</NameChangedFlag>
15           </ExitSegmentInfo>
16           <GeoPosition>
17              <Latitude>4201745</Latitude>
18              <Longitude>-8788161</Longitude>
19           </GeoPosition>
20        </Node>
21        <Context>
22           <ExitHeading>NORTH</ExitHeading>
23        </Context>
24        <DistToNextManeuver Units="Meters">756</DistToNextManeuver>
25        <DistFromOrigin Units="Meters">0</DistFromOrigin>
26        <TimeToNextManeuver>131</TimeToNextManeuver>
27        <TimeFromOrigin>0</TimeFromOrigin>
28        </Maneuver>
29        <Maneuver id="2">
30        <ManeuverType>6</ManeuverType>
31     <Node>
32        <EntrySegmentInfo>
33           <SegmentName>ORCHARD ST</SegmentName>
34           <NameChangedFlag>0</NameChangedFlag>
35        </EntrySegmentInfo>
36        <ExitSegmentInfo>
37           <SegmentName>E OAKTON ST</SegmentName>
38           <NameChangedFlag>1</NameChangedFlag>
39        </ExitSegmentInfo>
40        <GeoPosition>
41           <Latitude>4202426</Latitude>
42           <Longitude>-8788203</Longitude>
43        </GeoPosition>
44     </Node>
45     <Context>
46        <DestinationText>E OAKTON ST</DestinationText>
```

16

```
1        <TurnAngle>RIGHT</TurnAngle>
2        <ExitHeading>EAST</ExitHeading>
3      </Context>
4      <DistToNextManeuver Units="Meters">3038</DistToNextManeuver>
5      <DistFromOrigin Units="Meters">756</DistFromOrigin>
6      <TimeToNextManeuver>274</TimeToNextManeuver>
7      <TimeFromOrigin>131</TimeFromOrigin>
8     </Maneuver>
9      ...
10    <NumManeuver>4</NumManeuver>
11  </Direction>
12
```

13   IV.   THE DATA CONVERSION APPLICATION
14   ON THE CUSTOMER-INTERFACE SERVER

15   Referring to Figure 2, the language- and format independent data structure 420 is

16   transmitted from the navigation-related information server 200 over the data network 140

17   to the customer-interface server 202(1). When the customer-interface server receives the

18   language- and format independent data structure 420, the data conversion application 240

19   extracts the maneuver data contained in the language- and format independent data

20   structure 420. The data conversion application 240 then develops maneuvering

21   instructions using the contents of the language- and format independent data structure

22   420. The maneuvering instructions are formed in a selected language of the end user that

23   requested the navigation-related information. In addition, when forming the maneuvering

24   instructions, the data conversion application 240 applies formatting to the instructions so

25   that the instructions are provided on the requesting end user's computing platform.

26   If the language- and format independent data structure 420 that the data

27   conversion application 240 receives from the navigation-related information server 200 is

28   in the XML format, the data conversion application 240 may use XML style sheets 460.

29   The style sheets 460 conform to the XML format used by the builder application 400.

30   In one embodiment, the data conversion application 240 provides the

31   maneuvering instructions to the end user's computing platform in HTML format. The

32   data conversion application 240 includes a style sheet for this purpose. According to this

33   embodiment, the HTML style sheets used by the data conversion application 240 uses the

34   XML data 420 provided from the navigation-related information server 200 and

35   generates an HTML data file that contains the maneuvering instructions in HTML

1   format. The HTML data file is then sent via the data network 140 to the end user's

2   computing platform 130 where the HTML data file can be used to present the

3   maneuvering instructions to the end user using any application that can handle HTML,

4   such as an Internet browser.

5

6   V.   <u>ADVANTAGES</u>

7   Several advantages follow from embodiments of the disclosed navigation

8   systems. The navigation systems allow end users that have different types of computing

9   platforms to obtain navigation services. The navigation systems also allow end users to

10   receive support in different languages. The disclosed embodiments achieve these

11   advantages by separating the functions of providing navigation-related information from

12   the customer-specific issues, such as specific language support and specific format

13   support.

14

15   It is intended that the foregoing detailed description be regarded as illustrative

16   rather than limiting and that it is understood that the following claims including all

17   equivalents are intended to define the scope of the invention.